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RECLAMATION PLAN FOR THE SEEP RIDGE PROJECT

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August 1984

5.0 REVEGETATION PLAN

There are two main reasons for revegetating the Seep Ridge Project Site following mining. The first reason is to control erosion; the second is to provide forage for livestock and wildlife to support the primary post-mining land use. Revegetation has been successfully performed on many sites similar to the Seep Ridge Project Area and there are few, if any, difficulties that will be faced during revegetation. One initial concern was residual heat above the retorts and its effect upon revegetation. However, research and field trials indicate that this is an ephemeral problem that can be corrected by species selection, season of revegetation, and the passing of time. The revegetation plan encompasses a wide variety of techniques so that adjustments can be made in field procedures without burdening the permit, the regulatory authority, and the operator with administrative delays during periods where timely action may be essential to revegetation success. The annual report (required by Rule M-8) will list the reclamation activities performed for a given year so that a permanent record is kept of the specific techniques that have been utilized. As described in the following revegetation sections, Geokinetics will exert whatever measures are needed in order to assure revegetation success.

5.1 SOIL PREPARATION

Throughout the West, it is evident that reclamation of mine sites is more rapid for areas where a seedbed can be prepared. Seedbed preparation does not necessarily require the use of elaborate machinery, although machines are commonly used to prepare seedbeds. The site conditions that are encountered at any given location will determine the degree of preparation that can be attained. Preparation can include hand raking, slope chaining, or techniques more associated with finish grading than with farming practices.

After final grading and after topsoil is replaced, site preparation will be accomplished in most cases using a chisel plow. Where hand broadcast seeding is necessary because of the inability to maneuver equipment on an area, raking will be employed as a postpreparation process. Other

equipment such as cultipackers, flex harrows, discs, toothed plows, or the like may be available on loan from time-to-time. Since these methods are approximately equivalent in terms of revegetation response, the kind of equipment used would be based upon slope, site shape, and the machinery available for pulling site preparation tools. Still, it is expected that chisel plowing will be the most versitile method available to the rolling terrain conditions found at Seep Ridge.

5.2 REVEGETATION TECHNIQUES

There are several means by which revegetation will occur on the project area. The primary revegetation method will be reseeding. Secondary revegetation will come about from topsoil transport and redistribution, airborne seed, and encroachment of plant species from adjacent vegetated areas. Occasional planting or transplanting may also be used to vary the growth forms on the reclaimed areas.

5.2.1 Reseeding

Both the baseline vegetation studies and the initial species trials were reviewed in coming up with the proposed seed mixes for revegetation of Seep Ridge (Table 5.1-5.3). There are three seed mixes that are proposed for the Seep Ridge area, one of which (Seed Mix #3, cover crop, Table 5.3) may never be needed. Seed Mix #1 (Table 5.1) will be used on the permanent revegetation areas. Seed Mix #2 (Table 5.2) will be used for topsoil stockpiles and temporary revegetation. Where several species are included as a group with a single broadcast rate (footnote 2, Table 5.1) all or only part of that poundage could be made up of any given species; the actual mix composition will be determined by what is commercially available and adapted to the Seep Ridge Site at the time of seeding. Native plant species have been emphasized. However, introduced species have also been used to meet specific management goals (e.g., introduced legumes to keep soils in stockpile in a viable condition) or, in limited quantities, to serve as successional species or to provide additional nutrition.

For use on areas that will be revegetated, a bulk seed additive (Table 5.4) will be included along with the main seed mix. This additive will be

Table __.5.1b Seed Mix #1 - Adaptability to Site Variations

Dry Sites:	Agropyron, Bouteloua, Elymus, Eragrostis, Oryzopsis, Sporobolus, Stipa, Astragalus, Atriplex, Ceratoides, Melilotus
Moist Sites:	Agropyron smithii, Agropyron dasystachyum, Elymus salina, Elymus cinereus, Bromus, Dactylis, Poa, Stipa, Astragalus, Melilotus
Warm Season:	Bouteloua, Eragrostis, Sporobolus, Astragalus, Atriplex, Ceratoides, Melilotus
Cool Season:	Agropyron, Bromus, Dactylis, Elymus, Oryzopsis, Poa, Stipa, Astragalus, Melilotus
Sand Adapted:	Agropyron dasystachyum, Elymus salina, Elymus triticoides, Eragostis, Oryzopsis, Sporobolus cryptandrus, Melilotus
Silt Adapted:	All species listed.
Clay Adapted:	Agropyron cristatum, Agropyron desertorum, Agropyron smithii, Agropyron spicatum, Agropyron spicatum v. inerme, Agropyron trachycaulum, Bouteloua, Dactylis, Elymus, Poa, Sprobolus airoides, Stipa, Astragalus, Atriplex, Ceratoides, Melilotus
Comments:	Quick covering species include Agropyron cristatum, A. desertorum, Dactylis, Elymus, and Stipa. Leguminous species (Melilotus and Astragalus) are included for nitrogen replenishment. Rhizomatous species, although slower growing than the quick greening species and other bunch grasses, have been used for soil stabilization. The rhizomatous species included in this mix are Agropyron dasystachyum, Agropyron smithii, Bouteloua gracilis (under stress), Bromus inermis, Elymus salinus, Elymus triticoides, and Poa compressa. Native plant species found on the site prior to oil shale development have been emphasized in the mix. Depending upon commercial availability 63 to 91% of the mix (by seed number) will be native. Likewise, 58% of the mix (by seed number) will be of species found on the site prior to development. Other natives such as Hilaria and Sitanion could have been added, but it is believed that sufficient amounts of these will establish through topsoil replacement. Other introduced species such as Agropyron trichophorum, Agropyron intermedium, and Medicago sativa could have been included but they were used in the other mixes (i.e., the Bulk Seed Mix and the Topsoil Stockpile Seed Mix.).

Table __.5.2a Seed Mix #2 for Topsoil Stockpiles and Temporary Revegetation at GKI's Seep Ridge Project

Species		Broadcast Rate lbs. pls/acre[1/]
Agropyron dasystachyum	Thickspike Wheatgrass.....	2
Agropyron desertorum	Desert Wheatgrass.....	1
Agropyron trachycaulum	Slender Wheatgrass.....	2
Agropyron trichophorum	Pubescent Wheatgrass.....	3
Bromus inermis	Smooth Brome.....	2
Dactylis glomerata	Common Orchardgrass.....	2
Festuca ovina v. duriuscula	Hard Sheep Fescue.....	2
Poa compressa	Canada Bluegrass.....	1
Medicago sativa	Alfalfa.....	5
Melilotus officinalis	Yellow Sweetclover.....	5
	TOTAL	25

1/ Pounds of pure live seed per acre.

Table __.5.2b Seed Mix #2 - Adaptability to Site Variations

Dry Sites:	Agropyron, Melilotus
Moist Sites:	Bromus, Dactylis, Festuca, Poa, Medicago
Warm Season:	Medicago, Melilotus
Cool Season:	All species listed.
Sand Adapted:	Agropyron dasystachyum, Melilotus
Silt Adapted:	All species listed.
Clay Adapted:	All species listed except for Agropyron dasystachyum
Comments:	The leguminous fraction, by far and away, is the most important component of this mix. Whether on topsoil stockpiles or on areas requiring temporary revegetation, the legumes (Medicago and Melilotus) will help to maintain or build the soil. Quick green growth will be provided by Agropyron desertorum, A. trachycaulum, Dactylis and Festuca. Soil holding by means of sod forming (rhizomatous) species is provided by Agropyron dasystachyum, A. trichophorum, Bromus, and Poa. Although the mix is primarily introduced, it is proposed for use on short-term situations rather than permanent revegetation.

Table __.5.3 Seed Mix #3 for Cover Crop at GKI's Seep Ridge Project

Seeding Season 1/	Species	Broadcast Rate lbs. pls/acre 2/
Late Summer	Triticum aestivum	Bread Wheat 25
Spring	Hordeum vulgare	Sixrow Barley 25

1/ Cover crop should be chosen by season. A winter wheat crop works well for late summer seeding, whereas barley is best suited to spring seeding. Oats, millet, and rye should be avoided because of their ability to set seed and to compete with perennial species. Barley varieties which have in the past proven well suited to mined land reclamation include Ladd Barley and Steptoe Barley. The more stems and less seed that a barley produces, the better it is suited for use as a cover crop.

2/ Pounds of pure live seed per acre.

Table __.5.4 Bulk Seed Additive for Permanent Revegetation at GKI's Seep Ridge Project

At least 5 lbs. (bulk) per acre of the following bulk seed additive will be seeded along with Seed Mix #1 during initial seeding of areas to be permanently revegetated. The Bulk Seed Additive may also be used alone or in combination with other seed mixes during interseeding. As many of the following species as are readily commercially available will go into the Bulk Seed Mix.

Grasses and Grasslike Species	(1 lb.)
Agropyron elongatum	Tall Wheatgrass
Agropyron intermedium	Intermediate Wheatgrass
Agropyron trichophorum	Pubescent Wheatgrass
Agrostis alba	Redtop Bent
Bromus biebersteinii	Meadow Brome
Carex spp.	Sedge species
Elymus canadensis	Canada Wildrye
Elymus junceus	Russian Wildrye
Hilaria jamesii	Galleta Hilaria
Oryzopsis micrantha	Littleseed Ricegrass
Sitanion hystrix	Bottlebrush Squirreltail
Spartina gracilis	Aklali Cordgrass

Forbs	(1 lb.)
Antennaria parvifolia	Smalleaf Pussytoes
Arenaria spp.	Sandwort species
Abronia spp.	Sandverbena species
Anagallis arvensis	Scarlet Pimpernel
Achillea millefolium	Common Yarrow
Achillea lanulosa	Western Yarrow
Aquilegia caerulea	Colorado Columbine
Aster tanacetifolius	Tansyleaf Aster
Cheiranthus allinonii	Siberian Wallflower
Chrysanthemum leucanthemum	Oxeyedaisy Chrysanthemum
Coreopsis lanceolata	Thickleaf Coreopsis
Delphinium nelsonii	Nelson Larkspur
Delphinium nuttallianum	Nuttall Larkspur
Gaillardia aristata	Common Blanketflower
Gaillardia pulchella	Rosering Blanketflower
Gilia aggregata	Skyrocket Gilia
Gilia caitata	Globe Gilia

Table __.5.4 Continued

Forbs - Continued	
Haplopappus acaulis	Stemless Goldenweed
Haplopappus spp.	Goldenweed spp.
Hymenoxis acaulis	Stemless Actinea
Cryptantha spp.	Cryptantha species
Iberis semperflorens	Perennial Candytuft
Linum grandiflorum	Flowering Flax
Linum lewisi	Lewis Flax
Linum perenne	Perennial Flax
Mirabilis spp.	Fouroclock species
Oenothera caespitosa	Tufted Eveningprimrose
Oenothera lamarckiana	Lamark Eveningprimrose
Oenothera pallida	Pale Eveningprimrose
Oenothera strigosa	Evening Primrose
Papaver nudicaule	Iceland Poppy
Penstemon fremontii	Fremont Penstem
Penstemon palmeri	Palmer Penstem
Penstemon strictus	Rockymountain Penstem
Penstemon spp.	Penstem species
Phlox longifolia	Longleaf Phlox
Phlox spp.	Phlox species
Ratibida columnaris	Upright Prairieconeflower
Rudbeckia hirta	Blackeyed Susan
Senecio multilobatus	Lobeleaf Groundsel
Sphaeralcea coccinea	Scarlet Globemallow
Sphaeralcea munroana	Munro Globemallow
Sphaeralcea ambigua	Desert Globemallow
Hedysarum borale	Northern Sweetvetch
Hedysarum spp.	Sweetvetch Species
Half-Shrubs, Shrubs, and Trees	(3 lbs.)
Artemisia frigida	Fringed Sagewort
Artemisia tridentata	Big Sagebrush
Atriplex confertifolia	Shadscale Saltbush
Atriplex gardneri	Gardner Saltbush
Atriplex tridentata	Saltbush
Atriplex spp.	Saltbush species
Amelanchier utahensis	Utah Serviceberry
Cercocarpus montanus	True Mountainmahogany
Chrysothamnus spp.	Rabbitbrush Species

Table __.5.4 Continued

Half-Shrubs, Shrubs, and Trees - Continued

Ephedra viridis	Green Mormontea
Purshia tridentata	Antelope Bitterbrush
Cowania mexicana	Mexican Cliffrose
Lycium halimifolium	Matrimonyvine Wolfberry
Artemisia nova	Black Sagebrush
Ephedra nevadensis	Nevada Mormontea
Rhus trilobata	Skunkbush Sumac
Kochia prostrata	Prostrate Summercypress
Atriplex obovata	Obovateleaf Saltbush
Berberis fremontii	Fremont Barberry
Cupressus nevedensis	Nevada Cypress
Rosa woodsii	Woods Rose

seeded at a rate of at least 5 bulk lbs/acre. The main purpose of the additive is to promote species diversity. It includes seed of normally low germination, shrub and forb seed, site collected seed, wildflowers, or other available seed that would be used on a limited basis. Because germination is expected to be low, cost high, and revegetation fully successful without the use of a bulk additive, a bulk seed rate is used (instead of a pure live seed value) in order to maintain a cost-effective approach to enhancing species diversity.

Where viability and availability allow, site collected seed will be utilized. Wherever possible, other seed used will be certified and legume seed will be innoculated.

Previous seeding on the Seep Ridge Area has been done using a variety of equipment; most recently a Brillion seeder was employed. Past seeding has been done both in the fall and the spring and it appears that adequate plant establishment occurs after either season, if there is enough moisture in the soil to get the plants through the seedling stage. Fall seeding would be done as late into the season as the weather will allow. This helps to prevent seed from eroding or premature weathering. Spring planting would be done as early as possible (as soon as the snows melt) in order to place seed into optimal moisture conditions. Therefore, spring seeding normally occurs in April and May, while fall seeding can begin in late October and continue into December. Many areas (e.g., Black Mesa Mine and Kayenta Mine in northern Arizona) have been successfully revegetated during summer seeding. Seed is distributed during times when there is little chance of precipitation. The seed is covered and lays in wait for early fall moisture. Enough growth takes place in the fall that plants are beyond the seedling stage when winter comes. Therefore, it is anticipated that interseeding could occur, or areas of critical stabilization could be seeded, in the summer as well as the early spring or late fall. The actual site conditions (soil and climate) encountered at any given time will determine when seeding, interseeding, or reseeding will occur. Under all circumstances, seeding will be accomplished the first favorable seeding season following topsoil replacement.

The number of species and seeds per species that are chosen must reflect the overall purpose of seeding. According to DePuit et al. (1980), the number of species and seeding rates were not observed to have an effect upon dominance of a few species. The kind of seeding (i.e., drill vs. broadcast) had an effect upon diversity; broadcast seeding and the increasing of the number of species seeded both gave an initial increase in diversity. Most importantly, productivity was maximized when drilling was at approximately 37 lbs. (bulk seed) per acre, however, with broadcasting productivity was maximized at approximately 75 lbs. (bulk seed) per acre.

Range interseeding uses a different philosophy than reclamation seeding. The number of species and the seeding rate are low in order to avoid competition to existing vegetation. Range interseeding is only appropriate for reclamation projects on areas that have been initially seeded and were not fully successful. Therefore, it is expected that during the growing season following initial reseeding of disturbed areas at Seep Ridge, Geokinetics will make an inspection and evaluation of revegetation. Where establishment is slow or there are barren areas that are not expected to readily fill in, an interseeding effort will be made. All or some of the species of Seed Mix #1 will be used for reseeding at a rate up to the original seeding rate.

5.2.2 Planting and Transplanting

Planting and transplanting may be used occasionally to supplement the reseeding effort. This will be done to diversify plant growth forms primarily because avian species and other wildlife readapt to an area more readily when there are a variety of plant heights available. Vertical stratification of wildlife habitat will also be accomplished by strategically reusing rock rubble and larger vegetation that was cleared before topsoil removal. These larger plants will also serve as cover to help promote big game movement through these areas. However, Restoring Big-Game Range in Utah (Plummer, 1968) gives much more emphasis to the need for food production for wildlife than to cover. This is probably because many ranges have an overabundance of woody cover. Therefore, Geokinetics plans to establish cover for animal movement in addition to establishing forage. Table 5.5 lists species that are suited to planting and transplanting.

Table __.5.5 Species Suited to Planting and Transplanting[1/]

Artemisia frigida	Fringed Sagewort
Atriplex canescens	Fourwing Saltbush
Atriplex species	Saltbush species
Cowania mexicana	Mexican Cliffrose (par. Stansbury)
Cercocarpus montanus	True Mountainmahogany
Ceratoides lanata	Common Winterfat
Ephedra nevadensis	Neveda Mormontea
Ephedra viridis	Green Mormontea
Kochia prostrata	Prostrate Summercypress
Rosa woodsii	Woods Rose

1/ Rates are not listed because planting and transplanting are supplemental to seeding. In no case would total planting of an area equal more than 90% of the premining shrub and tree density.

Juniper and pinyon pine will not be planted or transplanted since these species should readily invade from adjacent areas.

Planting, transplanting, and the distributing of rock and woody rubble will be done after an area has been seeded so that impediments would not be created for the seeding process. Any needed interseeding would be accomplished by hand-broadcasting and would not be hindered by the planting or transplanting.

Hand planting methods will be employed where planting is used. Proper storage and handling of nursery stock will be exercised until all stock is planted. Planting will be done in the fall after dormancy or in the spring prior to greening. Soil moisture will be the most important factor in determining when to plant. Containerized or bareroot stock will be used depending upon the species chosen. A slow release fertilizer tablet may also be used if it is expected that soil nutrient levels are marginal. However, fertilizer has often caused a higher mortality rate to young plants due to wildlife forage preferrence (Burlington Northern Timberlands, John Grant, personal communication).

Transplanting of material on the site, if used, will be accomplished by spade, end-loader, or hand transplanting means. Soil sections or plugs containing living plants is the most common type of transplant, although slips or cuttings have occasionally been used with success.

5.3 FERTILIZER AMENDMENTS

It is expected that the revegetaton at the Seep Ridge Project site can be accomplished without the use of fertilizer amendments. As was indicated in the soil section of the reclamation plan (__.2) the use of a fertilizer amendment is not anticipated unless the nutrient analyses indicate that a fertilizer is necessary and Geokinetics determines that reclamation would not be successful for a particular area unless a fertilizer amendment is used.

Legumes have been included in the seed mixes in order to avoid having to apply nitrogen fertilizers. These legumes are moderately long-lived but will be out-competed eventually by the grass component of the seed mix

(Templeton, 1976). This gives several years of sustained nitrogen fixation, and then allows for the succession of species into the permanent vegetative cover. At revegetation test plots established by Colorado State University (CSU) in the Piceance Basin, it was seen that nitrogen fertilizers gave vegetative growth an initial advantage. This testing, which was done on spent oil shale sites in the Piceance Basin, also demonstrated that initial fertilizer advantages were no longer significantly detectible from control plots after 3 or 4 growing seasons (personal communications, Edward Redente, CSU Range Department).

Finally, it is necessary to note that even though only nutrient testing is anticipated for areas with recently replaced topsoil, the reclamation costs (Section __.9) include the estimated cost of fertilizer amendments, if they are necessary.

5.4 MULCH

Thus far, mulches have not been needed in order to perform successful revegetation on Seep Ridge revegetation test plots. Soils at Seep Ridge are of a loamy nature and are not particularly susceptible to wind or water erosion. The proper preparation of a seedbed, reduction of slopes to the maximum extent possible, and the practice of seeding at the earliest opportunity following topsoil replacement and final grading will minimize erosion. Mulch application might have a short-term benefit, but could prove detrimental over the long run, depending upon the kind of mulch applied. For example, use of hays and straws can lead to severe weed infestations, wood fiber can so seal the surface that germination is inhibited, wood chips from certain tree species may create a phytotoxic soil condition. Even where a suitable mulch is applied, significant differences in vegetative production and erosion control are often not seen. Such was the case at the CSU revegetation test plots in the Piceance Basin (personal conversations, Edward Redente, CSU Range Department).

Another mulch technique that has been used for areas with loose soils and adequate (above 10") precipitation is green mulching (live mulching). A cover crop (Seed Mix #3, Table __.5.3) is planted and before it has a chance to mature (set seed), it is disced into the soil surface. The

perennial seed mix (Seed Mix #1, Table __.5.1) can be broadcasted just prior to discing or drilled following discing. Where a Brillion-type seeder is used, as in the past, seeding after discing would be appropriate. As with other mulching, green mulching has its disadvantages. A risk of residual cover crop out-competing perennial crop exists as does the possibility that delay to permanent revegetation could result in increased erosion.

Although mulching of any kind is not proposed at this time, the possibility of mulch trials or limited mulching has not been completely ruled out. Therefore, the reclamation costs (Section __.9) include mulching, although such a practice may actually never be needed.

5.5 IRRIGATION

Continual irrigation is not proposed. Some initial work has been done with seedbed irrigation on a one time basis for germination assistance at the Seep Ridge Project Area. Where water, the equipment, and manpower are available and where the site conditions warrant, due to drought or soil type, one-time seedbed irrigation may be employed. This measure is proposed entirely as an alternative to the cost that could be associated with interseeding or reseeding. Because the reclamation costs (Section __.9) include a potential cost for interseeding, irrigation for seedbed establishment has not been included. The exclusion of irrigation cost is also appropriate from the standpoint that reclamation will be fully successful even if areas are not irrigated. This is consistent with the CSU Piceance Basin test plot results where, by the fourth year there were no longer significant production differences between the nonirrigated and irrigated plots, even after two years of supplemental watering (personal communication, Ed Redente, CSU Range Department).

5.6 NOXIOUS WEEDS

None of the twelve Utah noxious weed species have been found on the Seep Ridge Project area. A past species list misnamed Euphobia robusta as "Leafy Spurge" (Euphorbia esula). However, subsequent lists have corrected this to "Robust Spurge" and no occurrences of Euphorbia esula have been found.

Should noxious weeds occur on the site, they would be controlled in a manner consistent with the Utah Noxious Weed Control Act.